Use Cases for IKE from Operational Quantities

Mark Powell, 6-27-2008

1. IKE from operational R_{33}, R_{26}, R_{18}, V_{MS}, R_{max}

The equations published in the Appendix of the BAMS article were based on H*Wind radii and produce inconsistent results when used with operational radii, which tend to be smaller than H*Wind radii (Moyer et al., 2007). A new set of equations was developed to estimate quadrant contributions to IKE, based on operational radii based on simple assumptions for estimating the mean wind between two radii. The radii values are available from the advisory / forecast text products, while the Rmax is available in the CARQ files. For forecast values when Rmax is not available, assume persistence.

For example in a given quadrant:

A. IKE_{TS-26} the IKE contribution by winds > tropical storm force but < 26 m/s (50 kts):

1. If $R_{26}>0$:

   For the NE quad contribution by winds > tropical storm force we assume the mean wind between the tropical storm and 26 m/s contour is 20 m/s, and the area is
   $1/4\ Pi\ (R_{18}{}^2 - R_{26}{}^2)$ hence:

   $IKE_{TS-26} = 0.5 * 20^2 * 1/4\ Pi\ (R_{18}{}^2 - 0.75\ R_{max}{}^2)$

2. If no R_{26}:

   a. If $V_{MS} > 26$ and $R_{18} > R_{max}$:
   The mean wind for the area of the quadrant with winds over tropical storm force is assumed to 20 m/s.

   $IKE_{TS-26} = 0.5 \times 20^2 * 1/4\ Pi\ (R_{18}{}^2 - 0.75\ R_{max}{}^2)$

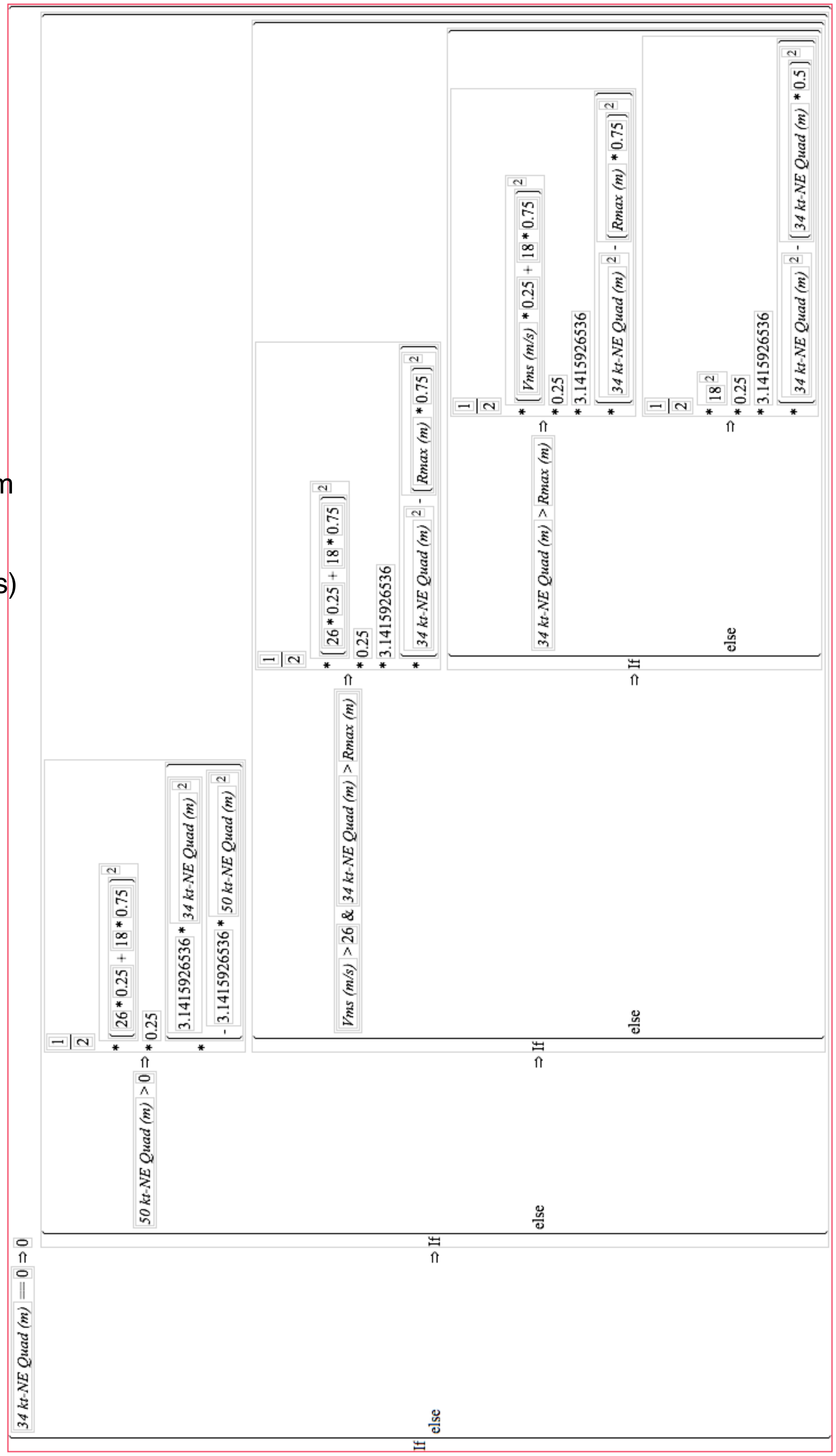
   b. If $V_{MS}<26$ and $R_{18} > R_{max}$, the mean wind is: $1/4\ V_{MS} + 3/4\ (18) = 0.25\ V_{MS} + 13.5$
   Winds > TS force extend from $0.75\ R_{max}$ outward to R_{18}. Therefore the corresponding area is $1/4\ Pi\ (R_{18}{}^2 - 0.75\ R_{max}{}^2)$.

   $IKE_{TS-26} = 0.5 \times (0.25\ V_{MS} + 13.5)^2 * 1/4\ Pi\ (R_{18}{}^2 - 0.75\ R_{max}{}^2)$

   c. If $R_{max} = R_{18}$, the mean wind is assumed to be 18 m/s and R_{max} is assumed to be 0.5 R18. Therefore the area is $1/4\ Pi\ [R_{18}{}^2 - (0.5 R_{18})^2]$

   $IKE_{TS-26} = 0.5 \times (18)^2 * 1/4\ Pi\ (R_{18}{}^2 - (0.5\ R_{18})^2)$

JMP Calculation for IKE from NHC wind radii for NE quadrant. IKE for winds > 34 kts but < 50 kts (26 m/s)



B. IKE_{26-33} the IKE contribution by winds >26 m/s but < 33 m/s

1. If $R_{33} > 0$:
The mean wind is 1/4 (33) + 3/4 (26) = 27.75 m/s and the area is 1/4 Pi $(R_{26}^2 - R_{33}^2)$.

$IKE_{26-33} = 0.5 * 27.75^2 * 1/4\ Pi\ (R_{26}^2 - R_{33}^2)$

2. If no R_{33}:
If $V_{MS} > 33$ and $R26 > R_{max}$,
The mean wind is 1/4 (33) + 3/4 (26) = 27.75 m/s and the area is 1/4 Pi $(R26^2 - .75\ R_{max}^2)$

$IKE_{26-33} = 0.5 * 27.75^2 * 1/4\ Pi\ (R26^2 - .75\ R_{max}^2)$

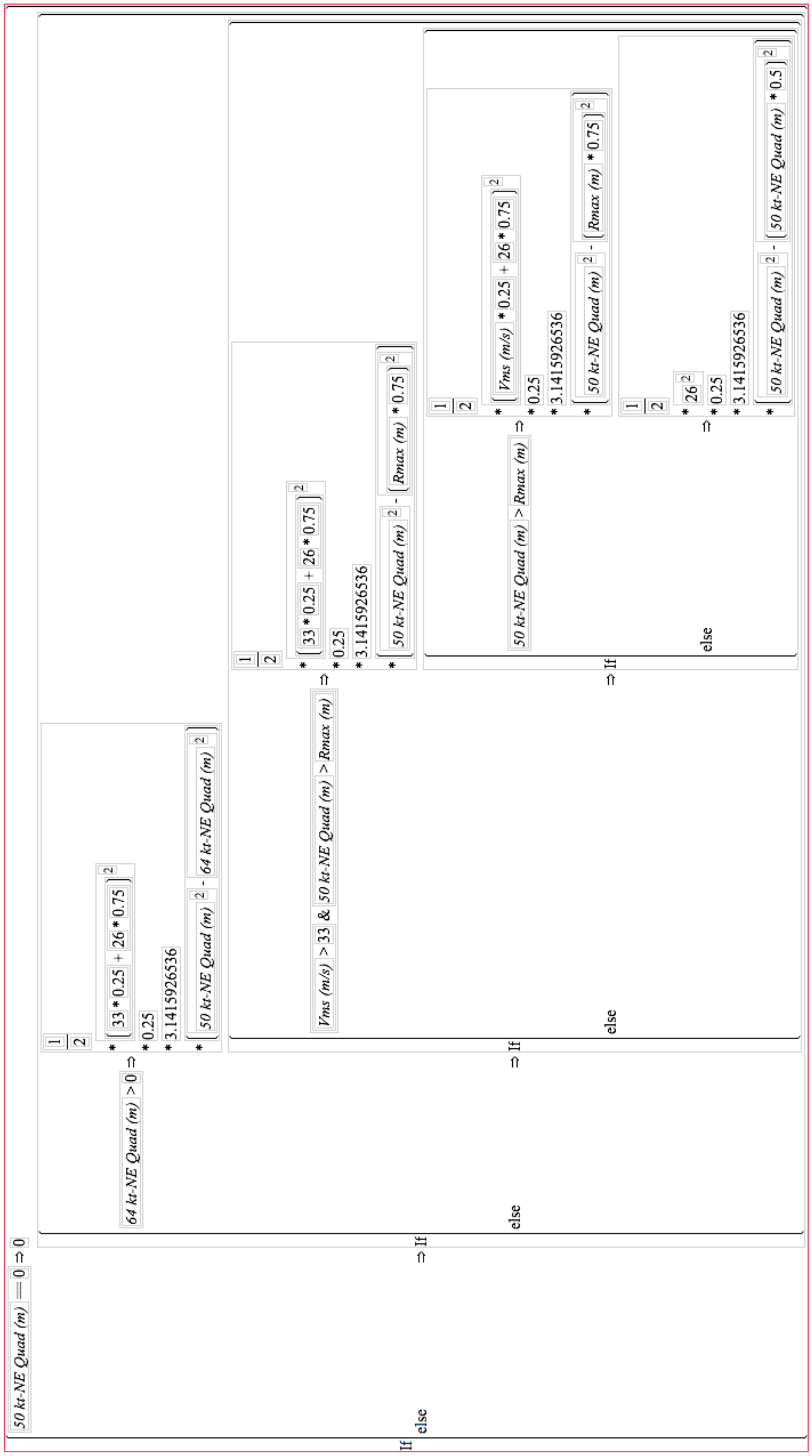
If $V_{MS} < 33$ and $R26 > R_{max}$,
the mean wind is $(.25\ V_{MS} + .75\ (26))$ and the area is 1/4 Pi $(R26^2 - .75\ R_{max}^2)$

$IKE_{26-33} = 0.5 * (.25V_{MS} + 19.5)^2 * 1/4\ Pi\ (R26^2 - .75\ R_{max}^2)$

If $R26 = R_{max}$, the mean wind is 26 and the area is: 1/4 Pi $[\ R_{26}^2 - (.5R_{26}^2)\ ]$

$IKE_{26-33} = 0.5 * 27.75^2 * 1/4\ Pi\ (R26^2 - (.5R_{26}^2))$

JMP Calculation for IKE from NHC wind radii for NE quadrant. IKE for winds
> 50 kts (26 m/s) but < 64 kts (33 m/s)



C. *IKEh: The contribution by winds > 33 m/s*

1. If the quadrant has the largest R_{33} of all quadrants:

   If $R_{33} > R_{max}$, Mean wind is $(.25V_{MS} + .75(33))$ and area is $1/4\ Pi\ (R_{33}^2 - .75R_{max}^2)$

   $IKEh = 0.5 * (.25V_{MS} + 24.75)^2 * 1/4\ Pi\ (R_{33}^2 - .75R_{max}^2)$

   If $R_{33} <= R_{max}$, Mean wind is Mean wind is $(.25V_{MS} + .75(33))$, area is $1/4\ Pi\ (R_{33}^2 - .75\ R_{33}^2)$

   $IKEh = 0.5 * (.25V_{MS} + 24.75)^2 * 1/4\ Pi\ (R_{33}^2 - .75\ R_{33}^2)$

2. If R_{33} is not the max R_{33} of any quadrant,

   If $R_{max} < R_{33}$ Mean wind is $(0.1V_{MS} + .9(33))$, Area is $1/4\ Pi\ (R_{33}^2 - .75\ R_{max}^2)$
   $IKEh = 0.5 * (0.1V_{MS} + 29.7)^2 * 1/4\ Pi\ (R_{33}^2 - .75\ R_{max}^2)$

   If $R_{max} >= R_{33}$ Mean wind is $(0.1V_{MS} + .9(33))$, Area is $1/4\ Pi\ (R_{33}^2 - .75\ R_{33}^2)$
   $IKEh = 0.5 * (0.1V_{MS} + 29.7)^2 * 1/4\ Pi\ (R_{33}^2 - .75\ R_{33}^2)$

JMP Calculation for IKE from NHC wind radii for NE quadrant. IKE for winds > 64 kts (33 m/s)

If $\mathit{Vms\ (m/s)} < 33 \mid \mathit{64\ kt\text{-}NE\ Quad\ (m)} == 0 \Rightarrow 0$

else $\Rightarrow$ If

$$\mathit{Rmax\ (m)} < \mathit{64\ kt\text{-}NE\ Quad\ (m)} \Rightarrow \frac{1}{2} * \left(\frac{\mathit{Vms\ (m/s)} + 33}{2}\right)^2 * 0.25 * \left(3.1415926536 * \mathit{64\ kt\text{-}NE\ Quad\ (m)}^2 - 3.1415926536 * \left(\mathit{Rmax\ (m)} * 0.75\right)^2\right)$$

$$\text{else} \Rightarrow \frac{1}{2} * \left(\frac{\mathit{Vms\ (m/s)} + 33}{2}\right)^2 * 0.25 * \left(3.1415926536 * \mathit{64\ kt\text{-}NE\ Quad\ (m)}^2 - 3.1415926536 * \left(\mathit{64\ kt\text{-}NE\ Quad\ (m)} * 0.75\right)^2\right)$$

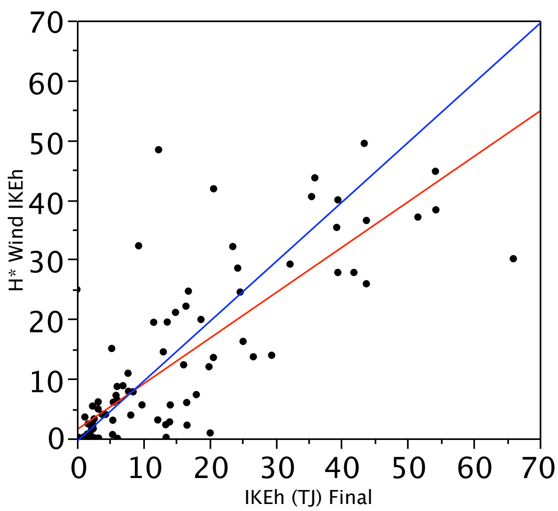
Table 1. Guidelines for computing integrated kinetic energy from operational quantities

Quadrant IKE Contribution	Criteria	Mean Wind ($m\ s^{-1}$)	Area
$IKE_{18\text{-}26}$	$R_{26} > 0$	20	1/4 Pi ($R_{18}{}^2$-$R_{26}{}^2$)
	No R_{26}, $V_{MS} > 26$, $R_{18} > R_{max}$	20	1/4 Pi ($R_{18}{}^2$-0.75 $R_{max}{}^2$)
	No R_{26}, $V_{MS} < 26$, $R_{18} > R_{max}$	1/4 V_{MS} + 3/4 (18)	1/4 Pi ($R_{18}{}^2$-0.75 $R_{max}{}^2$)
	No R_{26}, $R_{max} = R_{18}$	18	1/4 Pi ($R_{18}{}^2$- $(0.5R_{18})^2$)
$IKE_{26\text{-}33}$	$R_{33} > 0$	27.75	1/4 Pi ($R_{26}{}^2$-$R_{33}{}^2$)
	no R_{33}, $V_{MS} > 33$, $R_{26} > R_{max}$	27.75	1/4 Pi ($R26^2$- .75 $R_{max}{}^2$)
	no R_{33}, $V_{MS} < 33$, $R_{26} > Rmax$	.25 V_{MS}+.75 (26)	1/4 Pi ($R26^2$- .75 $R_{max}{}^2$)
	no R_{33}, $R_{26} = R_{max}$	26	1/4 Pi [$R_{26}{}^2$- ($.5R_{26}{}^2$)]
IKE_H	Max R_{33} Quadrant, $R_{33} > R_{max}$	.25V_{MS} +.75(33)	1/4 Pi ($R_{33}{}^2$ - .75$R_{max}{}^2$)
	Max R_{33} Quadrant, $R_{33} = R_{max}$	.25V_{MS} +.75(33)	1/4 Pi ($R_{33}{}^2$ - .75 $R_{33}{}^2$)
	$R_{33} < R_{max}$	.1V_{MS} + .9(33)	1/4 Pi ($R_{33}{}^2$ - .75 $R_{33}{}^2$)
	Not max R_{33} Quadrant $R_{max} = R_{33}$	.1V_{MS} + .9(33)	1/4 Pi ($R_{33}{}^2$ - .75 $R_{max}{}^2$)

2. IKE_h

The IKE_h contributions from each quadrant are summed to compute the storm total IKE_h

$$\text{Storm total } IKE_h = IKE_{h\ NE} + IKE_{h\ SE} + IKE_{h\ SW} + IKE_{h\ NW}$$



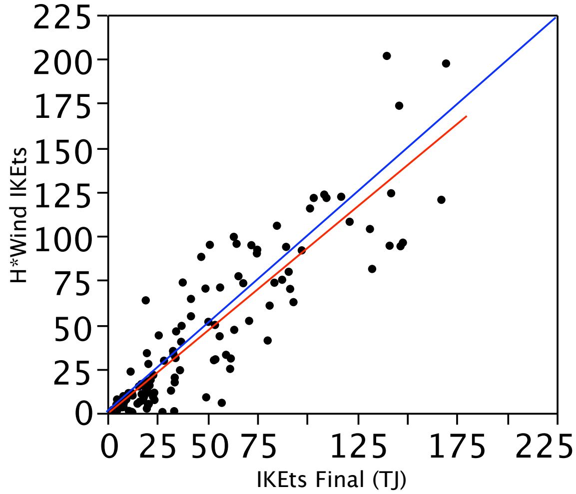
The IKEh comparison shows large scatter with an r^2 of 0.68 based on 110 cases. There is a tendency for the operational values to be larger than H*Wind for the stronger storms.

3. IKE_{TS}: The contribution by winds > tropical storm strength

If the $V_{MS} > 17.5$ m/s and $R_{18} > 0$,
The contributions from each quadrant are summed to compute the storm total IKE_{ts}

$$IKE_{TS} = IKE_{TS\text{-}26} + IKE_{26\text{-}33} + IKE_h$$

$$\text{Storm total } IKE_{TS} = IKE_{TSNE} + IKE_{TSSE} + IKE_{TSSW} + IKE_{TSNW}$$



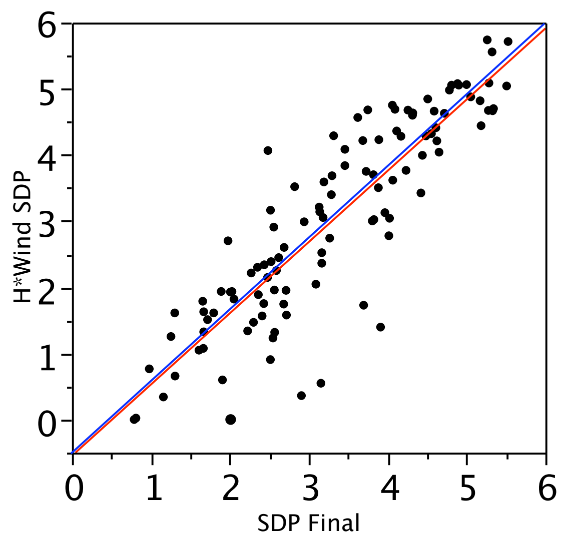
Comparisons of the H*Wind and operational estimates of IKE_{TS} compare very well (r^2 of 0.78).

4. Surge Destructive Potential SDP

This equation is the same that was published in BAMS.

$$SDP = 0.676 + 0.43\ (IKE_{TS})^{.5} - 0.0176(\ (IKE_{TS}{}^{.5}\ \ -6.5\ )^2$$

SDP computed from H*Wind and the operational information from the above equation compared well with an r^2 of 0.77 and no evidence of bias for 110 cases.



5. Sample calculations:

Sample Calculations NE Quadrant

Storm	MMdd hh	R34 (18) (m)	R50 (26) (m)	R64 (33) (m)	Rmax (m)	Vmss ($m\ s^{-1}$)	IKE_{TS-26} x 10^{12} Joules	IKE_{26-33} x 10^{12} Joules	$IKE_{>33}$ x 10^{12} Joules
H Wilma	101812	194460	55560	27780	27780	33.5	1.131	0.7001	0.1463
TS Beryl	072006	222240	74080	NA	55560	25.8	6.896	0.9905	0
H Rita	092106	222240	111120	74080	27780	56.6	5.818	2.074	3.982
H. Katrina	082818	370400	222240	166680	37040	77.3	13.79	6.53	32.18

NHC Wind Radii

Storm	MMddhh	Quadrant	R34 (18) (m)	R50 (26) (m)	R64 (33) (m)
H. Wilma	101812	NE	194460	55560	27780
		SE	138900	37040	27780
		SW	92600	37040	27780
		NW	194460	55560	27780
TS Beryl	072006	NE	222240	74080	NA
		SE	166680	74080	NA
		SW	111120	37040	NA
		NW	92600	37040	NA
H. Rita	092106	NE	222240	111120	74080
		SE	185200	83340	55560
		SW	111120	74080	46300
		NW	194460	111120	74080
H. Katrina	82818	NE	370400	222240	166680
		SE	333360	222240	166680
		SW	231500	138900	92600
		NW	333360	222240	166680

Sample Calculations:

Storm	MMddhh	IKETS (x 10^{12} Joules)	IKEH (x 10^{12} Joules)	Surge Destructive Potential (SDP)
H. Wilma	101812	17.205	0.57	2.36
TS Beryl	072006	15.78	0	2.27
H. Rita	092106	32.92	8.64	3.13
H. Katrina	082818	167.27	75.31	5.51

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References

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